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Non-Provisional Patent Application

for

AUTOMATED VOICE OVER IP DEVICE VLAN-ASSOCIATION SETUP

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CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. provisional application serial no. 60/437,215, entitled "COMMUNICATION NETWORK HAVING IP PHONE LOCATION ASSOCIATION," filed December 31, 2002, the contents of which is hereby incorporated herein by reference for all purposes.

FIELD OF INVENTION

The invention relates to Voice-over- Internet Protocol (IP) technology used to manage Voice-over-IP devices in a distributed network. In particular, the invention relates to a system and method for automatically transmitting system attributes including the Virtual Local Area Network (VLAN) identifier and physical connectivity information from a network node to a Voice-over-IP device.

BACKGROUND

When building data networks to support voice-over-IP (VoIP) communications it is often desirable to place the IP Phones in a separate VLAN from the other data devices in the network. This makes it easier for the switches in the network to provide the Quality of Service processing needed to ensure proper transmission of VoIP calls. The switches in the network are configured with the VLAN dedicated for VoIP traffic. The VLAN to which an IP phone belongs is identified using an IEEE 802.1Q tag with the VLAN value in the Ethernet frames, for example, generated by the device. After being assigned, the VLAN value is placed in the header of substantially all frames transmitted by the IP phone.

Unfortunately, the current protocols defined for distributing VLAN information between switches do not provide a mechanism to inform end users which VLAN should be used for purposes of sending traffic. The VLAN identification must therefore be manually configured in each VoIP phone either directly or through a network management tool. Such practices are both time consuming and raise the potential for human error. To add to the burden, it may be necessary to reconfigure an IP phone with a new VLAN if the IP phone is moved to a different switch or if the VoIP VLAN configuration of the switch is changed.

There are mechanisms for distributing information between switches about the VLANs configured on the respective switches and for distributing the information between switches to construct a topologic map of the network, for example. The Group Address

Resolution Protocol (GARP) VLAN Address Resolution Protocol (GVRP) standardized by the IEEE in IEEE Standard 802.1Q-1998 - IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks provides a mechanism for conveying information between switches in the network about the IEEE 802.1Q VLANs configured on the switches and on which ports of the respective switches these VLANs are configured. In particular, the IEEE 802.1Q standard defines an architecture for Virtual Bridged LANs, the services provided in Virtual Bridged LANs, and the protocols and algorithms involved in the provision of those services. However, no such mechanism has been defined for communicating VLAN configuration information from a network device to an end system.

In addition to communicating VLAN configuration information to a VoIP phone, it is also desirable to communicate physical location information from the phone to an IP private branch exchange (PBX). Enhanced 911 solutions, for example, require that phone systems such as IP PBXs provide physical location information with a 911 call using a mechanism called the automatic location indicator (ALI). The ALI allows an emergency service provider to automatically determine the physical location of the person placing the 911 call. The current state of the art for associating physical location information with the phone number that identifies a telephone uses an external database. The PBX then consults this external database when processing a 911 call to extract the physical location information associated with the telephone placing the 911 call. The location information in the external database must be manually entered and is inaccurate when a phone is moved to new locations in the network until the database is manually updated.

There is therefore a need for a system and method to automatically communicate VLAN information to IP phones and to automatically convey physical connectivity information to a central store with minimal human intervention, minimal delay, and maximal accuracy.

SUMMARY

The invention according to the preferred embodiment features a method that comprises steps for exchanging system attributes between at least one VoIP device and another node in the network. In some embodiments, the VoIP device is an IP phone and the node to which it is operatively coupled is an adjacent switching device or other addressable entities embodied in a processor, computer, or other appliance. The VoIP phone is preferably one of a plurality of devices that cooperate with an IP PBX employed in an enterprise network, for example.

The system attributes transmitted between the IP phone and other nodes may include, but are not limited to, one of the following: the VLAN identification of a VoIP VLAN assigned in the network, the switching device identification, slot number and port number to which the IP phone is connected. The identification, slot number, and port number may also be communicated to the IP PBX where they are used to relate the physical location of the port connection with the IP phone to which it is connected. The transmission of system attributes occurs automatically upon one of several triggering events, thereby avoiding the need for manual configuration of the system attributes.

In the preferred embodiment, the system attribute exchange comprises two messages, namely a first message referred to herein as a VoIP device identification message generated by the VoIP device, and a second message referred to herein as a VoIP device identification acknowledgment provided by the appropriate node in response. The VoIP device identification message notifies the node that the device is in fact a VoIP device for which a VLAN assignment is warranted. In response, the node automatically transmits the VoIP device identification acknowledgment including the one or more system attributes. In some embodiments, the VoIP device identification message is generated automatically when (a) the IP phone is operatively coupled to the network, generally at the time it is initialized, or (b) the switching device is initialized. In the later case, the VoIP device identification message may be automatically transmitted in response to a

node initialization message, i.e. a switching device notification message that elicits identifying information from adjacent devices.

The invention in some embodiments features a system for performing the connectivity-information exchange. The system generally includes at least one VoIP device such as an IP phone and a network device such as a switching device. The VoIP device and node are adapted to automatically send the VoIP device identification message and VoIP device identification acknowledgment in the manner described herein. With the system for performing the connectivity-information exchange, the VoIP VLAN to which the VoIP device is intended may be configured automatically with minimal or no manual intervention, thereby reducing the labor necessary to configure the VoIP network. The absence of human intervention may also increase the accuracy of a relational database used to report the physical location of an IP phone user to emergency response personnel, as described herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and not limitation in the figures of the accompanying drawings, and in which:

FIG. 1 is a distributed network topology with which the preferred embodiment of the present invention may be implemented;

FIG. 2 is a flow diagram illustrating a system attribute exchange between an IP phone and switching device upon initialization of the IP phone, according to the preferred embodiment of the present invention;

FIG. 3 is a flow diagram illustrating a system attribute exchange between an IP phone and switching device when the switching device is initialized or when the switching device detects that a new device has been connected to a port of said device, according to the preferred embodiment of the present invention; and

FIG. 4 is a packet definition with which the VoIP device identification message and VoIP identification acknowledgement may be generated, according to the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1, a distributed network topology with which the present invention may be implemented is illustrated. The network topology 100 comprises one or more subnets 110, which may include an intranet, a local area network (LAN), a wide area network (WAN), or a metropolitan area network (MAN), and/or the Internet, for example. The subnet 110 associated with the IP phone 102 is preferably an Ethernet network. Operably connected to the subnet 110 are a plurality of network devices including one or more VoIP communication devices 102, an IP PBX 104, and a switching device such as a bridge or router adapted to perform layer 2 and/or layer 3 switching operations as defined in the OSI network model.

The VoIP device in the preferred embodiment is an IP phone that operates in cooperation with the IP PBX 104 and/or other VoIP devices (not shown) using the Session Initiation Protocol (SIP), Real Time Protocol (RTP), or suitable alternative voice communication protocol. The IP phone 102 communicates indirectly with the IP PBX 104 by means of the switching device 108. As prescribed herein, the switching device 108 facilitates the formation and maintenance of an audio communication session between the VoIP communication device 102 and the IP PBX or between two VoIP communications devices 102. In some embodiments, the communication session also supports audio and video communication sessions.

In the preferred embodiment, the IP phone 102 is enabled with a VLAN tagging protocol, preferably 802.1Q or suitable equivalent, for purposes of incorporating a VLAN identifier (VID) in outgoing transmissions. The 802.1Q tag may be inserted by a software stack in the IP phone or by a network interface card, for example.

In prior art systems, the VID used by the IP phone 102 would necessarily be manually configured by the network administrator, which is both labor intensive and subject to human error. To overcome these limitations, the several embodiments disclosed herein provide a mechanism to automatically initiate an exchange referred to herein as the system attribute exchange. The system attribute exchange includes one or more messages or transmissions between the VoIP device 102 and the adjacent switching device 108 for purposes of distributing one or more system attributes to the VoIP device, including the appropriate VID, to be used by the device for VoIP communications. In some embodiments the system attributes comprises the VID used for VoIP communications, although the system attribute exchange may further convey information pertaining to the switching device identification, slot number, and port number associated with the IP phone 102.

The connectivity-information exchange may be initiated when the IP phone 102 is connected to the subnet 110 and initialized, when the switching device 108 is initialized, or when the switching device first detects the presence of a device, such as IP phone 102 connected to one of the switch ports.

Illustrated in FIG. 2 is a flow diagram of a system attribute exchange with an IP phone upon initialization of the IP phone. The IP phone 102 is initialized in step 204 when the phone is plugged into the network 110. This may occur when the phone is first coupled to the subnet 110 or when the IP phone is relocated in the subnet 110. In both cases, the IP phone 102 transmits a VoIP device identification (VDI) message 206. In this embodiment, the VDI message 206 is the first of a plurality of transmissions that constitute the system attribute exchange.

The primary purpose of the VDI message 206 is to announce the presence of the IP phone 102, i.e. to identify the IP phone 102 as a VoIP device to the adjacent switching device 108. The identity of the device as a VoIP device is important for purposes of including the IP phone 102 in the VLAN reserved for VoIP, and incorporating the IP phone 102

into the switching device's forwarding tables as soon as is reasonably possible. After the adjacent switching device 108 is provided notice of the installation of the IP phone 102, the IP PBX is also made aware of the presence of the IP phone 102 by means of a separate message exchange between the IP phone and the PBX, for example..

In the preferred embodiment, the VDI message 206 is generated by the IP phone 102 using what is referred to herein as an Attribute Advertisement Protocol (AAP). AAP may be used to communicate information including the VID or other attributes between AAP-enabled network devices such as the IP Phone 102 and adjacent switching device 108. Although AAP may incorporate one or more standard protocols, it is generally a localized solution supported by network devices of specific vendor using a non-standardized signaling convention enabled on various devices of the vendor. An advertisement protocol that may be adapted for purposes of this invention is taught in copending U.S. patent application no. 10/028,647, entitled "VLAN Advertisement Protocol," hereby incorporated by reference herein.

The VDI message 206 of the preferred embodiment, illustrated in FIG. 4, comprises an AAP version number, AAP type, VLAN identification, source port, media access control (MAC) address, flag field, IP address count and IP address, source host name, and clustering information. The purposes of the fields of the VDI message 206 are as follows:

a) Version number 402, preferably one byte, is assigned a value to distinguish it from other AAP packet versions;

b) AAP type field 404, preferably one byte, is used to distinguish the AAP message as being a VDI message from other AAP message types;

c) VID 406, preferably 2 bytes, is generally used to designate the VLAN of the device identified by the MAC address field, which assigned a value of zero since it is unknown to the IP phone 102 at the time of transmission;

d) Source Port 408, preferably two bytes, is generally used to specify the port on the switch to which the phone is attached. Typically this is the slot number and port

number where the IP phone is attached, but is assigned a value of zero since it is inapplicable to the IP phone 102;

e) Reserved 410, two bytes herein, is unused in the present embodiment;

f) MAC Address 412, 414, preferably six bytes, is used to specify the MAC address of the source device, IP phone 102;

g) Flags 416, preferably one byte, assigned the value zero for an initial VDI packet;

h) IP Address Count 418, preferably one byte, identifies the number of IP addresses contained in the frame, typically this is assigned a value of one;

i) IP Addresses 420, preferably multiple of four bytes, is used to specify the IP address(es) of the device identified by the MAC address. In the case of the IP phone this will typically be all zeros for the initial message;

j) Source Host System Name 422, preferably 32 bytes, is used to specify the name of source device, IP phone 102; and

k) Reserved 424, 16 bytes, is used in other AAP messages but not in VDI messages.

In the preferred embodiment, the VDI message 206 is incorporated into a packet having a special unicast MAC address since the MAC address of the switching device 108 is unknown to the IP phone 102 at the time of transmission. The MAC address used in some embodiments, 00-20-DA-00-70-04, is reserved for AAP communications between devices pre-configured to recognizes this address. Alternatively, a broadcast address of FF-FF-FF-FF-FF-FF can be used as the destination MAC address. Upon receipt, the frame including the AAP header 400 is forwarded to an AAP processing agent in the switching device 108 responsible for recognizing incoming AAP frames and generating the appropriate response.

When received, the switching device 108 forwards the VDI message 206 to software where the source device is determined to be a VoIP phone. In addition, the switching device also determines that the VDI message 206 is an introduction, in a manner of speaking, to which it must respond with further information. The response, generated in step 220, is a "VDI acknowledgement" 208 that informs the IP phone 102 of the VLAN

configuration in the switching device 108 for VoIP traffic and the 802.1Q value assigned to this VLAN, namely the VID 402. The VLAN specified by the switching device 108 to the IP phone 102 is preferably the only VLAN dedicated to VoIP within that particular segment of the subnet, although one skilled in the art will recognize that multiple VLANs may be set aside within an enterprise for voice data.

In the preferred embodiment, the VDI acknowledgement 208 further includes "connectivity information" which, when associated with the geographic distribution of the nodes of the network 106, can be used to geographically pinpoint the location of the IP phone 102. In the preferred embodiment, the connectivity information includes, but is not limited to, the switching device identification as well as the port identification including, for example, slot number and port number on which the IP phone 102 connects to the switching device 108. The VLAN information and the connectivity information described above are preferably communicated to the IP Phone 102 in the same packet, although a plurality of packets may also be employed. In addition, the VLAN used for VoIP is known to the switching device 108 as a result of one or more configuration messages entered via the switch console or received from a network management entity.

The VDI acknowledgement 208 of the preferable embodiment comprises an AAP version number, AAP type, VLAN identification, source port, MAC address, flag field, total IP address and IP address, source host name, and clustering information. The purposes of the fields of the VDI acknowledgement 208 fields are as follows:

a) Version number, preferably one byte, is assigned a value to distinguish it from other AAP packet versions;
b) AAP type, preferably one byte, is used to distinguish the AAP message as being a VDI message from other AAP message types;
c) VID, preferably 2 bytes, is used to designated the VLAN (or default VLAN of port) to be used by the VoIP device in its transmissions;
d) Source Port, preferably two bytes, is used to specify the port information, preferably source slot and port value to which the phone is attached;

e) Reserved, two bytes herein, is unused in the present embodiment;

f) MAC Address, preferably six bytes, is used to specify the medium access control (MAC) address of the source device, namely the switching device 108;

g) Flags, preferably one byte, assigned the value of one for a reply packet;

h) IP Address Count, preferably one byte, identifies the number of IP addresses contained in the subsequent fields, it is typically assigned a value of one;

i) IP Addresses, preferably multiple of four bytes, is used to specify the IP address of the switching device 108;

j) Source Host System Name, preferably 32 bytes, is used to specify the name of source device, namely the system name of the switching device 108; and

k) Reserved 424, 16 bytes, is used in other AAP messages but not in VDI messages.

The VDI acknowledgement 208 in the preferred embodiment uses the same frame format as that of the VDI message 206 with the appropriate modification of the values, as described immediately above. The VDI acknowledgement frame can be sent as a broadcast packet or with the MAC address of the IP phone as received in the initial frame from the IP phone.

Upon receipt of the VDI acknowledgement 208, the IP phone 102 makes a record of the VID. The VID is then included in subsequent communication VoIP communications until the VLAN is reconfigured or the IP phone re-initialized in another location having a different VoIP VLAN. These communications including incoming and outgoing calls initiated with connection request messages 210, 212 which, if answered 224 by the call recipient coupled to the IP-PBX 104 or public switched telephone network (PSTN) (not shown) result in connection acknowledgements 214, 216 that give rise to the voice communication messages 218A, 218B.

If the VDI acknowledgement 208 further includes the connectivity information or other system attributes, the IP phone 102 can directly or indirectly convey this information to the IP PBX 104 or alternative physical locality mapping device. The IP PBX 104, for

example, includes in some embodiments a relational database 106 having one or more tables that associate the switch, slot, and port numbers with the known geographic distribution of the nodes of the network 106. The database 106, which is preferably automatically updated with the initialization or installation of all VoIP devices, provides real-time access to the physical location of the IP phone 102 and substantially all other VoIP devices in the subnet 110. The database 106, or IP PBX 104 more generally, outputs the physical location of an individual IP phone 102 upon entry of one or more of the following: the device's extension number as known by the IP PBX, MAC address, switching device identification, slot number, and/or port number.

The embodiment of the invention therefore provides a method and system for automatically updating the VID of substantially all the VoIP devices in a subnet. The present invention represents a significant improvement over prior art systems that rely on the manual entry of a VoIP VLAN configuration which are prone to errors and are potential incorrect for some period of time after an IP phone is move, added, or otherwise changed.

A further embodiment encompasses a system and method incorporating IEEE 802.1x, which provides a control and authentication mechanism to regulate access between the IP phone 102 and switching device 108. Using an Extensible Authentication Protocol (EAP), for example, one or more of the messages exchanged between the IP phone 102 and the switching device 108 may comprise a machine credential used in cooperation with an authentication server to regulate access to the other. The IP phone 102 may be programmed or hardwired with the credentials needed by the authentication server for verification and assignment of a VoIP VLAN, or the VLAN assignment passed in an 802.1x message returned to the IP phone 102.

A further embodiment of the invention provides a method for providing physical connectivity information to VoIP devices to allow for automatic creation and updating of databases that contain the physical location of a given IP phone. A common practice

relies on manual updating of this data base and as a consequence, prior art system may provide inaccurate physical location information with a 911 call, thereby resulting in a possible delay in the arrival of emergency personnel. The ability to quickly, accurately, and unambiguously physically locate a person in an emergency response situation clearly has life and death consequences.

In a second embodiment of the invention illustrated in FIG. 3, the system attribute exchange is first initiated by the switching device 108 upon initialization which generally includes start up, boot up, installation, and re-installation. After the switching device 108 is initialized during the initializing step 304, the switching device 108 automatically generates a switching device initialization (SDI) message 305 that is transmitted out of each of its interfaces. The SDI message 305 elicits a response from adjacent devices for purposes of building or updating the connectivity tables used by the switching device 108. In the preferred embodiment, the SDI message 305 uses the same frame format as that of the VDI acknowledgement 208 with suitable modification of the values contained therein.

In response to the SDI message 305, the IP phone 102 preferably generates a VoIP device identity message, preferably VDI message 306, as illustrated in identifying step 302. The VDI message 306 is substantially equivalent to the VDI message 206, the principal exception being that the destination address of the packet includes the MAC address of the switching device 108 instead of the special purpose AAP MAC address.

The switching device 108 responds in the acknowledging step 322 to the VDI message 306 with a VDI acknowledgement message 308. The switching device 108, which now knows the identity of the IP phone 102, preferably transmits the appropriate VID and, in some embodiments, additional connectivity information. The VDI acknowledgement 308 in the preferred embodiment is substantially identical to the VDI acknowledgement 208.

Similar to the previously described embodiment, the completion of the system attribute exchange lays the foundation for subsequent voice communication 318A, 318B pursuant to an incoming call or outgoing call established by connection request messages 310, 312 and the connection acknowledgement messages 314, 316, when the call is answered 324 by a recipient (not shown). Again, the connection requests messages 310, 312 and the voice communication messages transmitted to the IP PBX 104 include the VID provided by the switching device 108 in the VDI acknowledgement 308. The switching device 108, in turn, is programmed in the VoIP VID by the network administrator or learned from another node in the network 106 by means of a VLAN registration message 302.

Although the description above contains many specifications, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of this invention.

Therefore, the invention has been disclosed by way of example and not limitation, and reference should be made to the following claims to determine the scope of the present invention.